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Original Article

The Relationship between Central Corneal Thickness and Intraocular Pressure in Adult Nigerians without Glaucoma

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ABSTRACT

The aim of this study was to investigate the relationship between central corneal thickness (CCT) and intraocular pressure (IOP) in a predominantly black population. A total of eighty-five subjects (right eyes) with mean age 44.7 ± 15.1 years consisting of 49 males and 36 females were recruited for this study. The central corneal thickness was measured by ultrasound pachymetry (SW-1000P pachymeter, Tianjin Suowei Electronic Technology, China) and intraocular pressure with Keeler Pulsair EasyEye Non-contact tonometer (Keeler Instruments, USA). The mean CCT for the studied population was 550.0 ± 36.3µm, while the mean IOP was 15.0 ± 2.6mmHg. Although there was a downward trend in the central corneal thickness towards the older age, the association between CCT and age was significant (r=-0.25, p=0.021). However, the association between intraocular pressure and age was not significant (r=0.091, p=0.41). There was no significant association between CCT and IOP (r=0.052, p=0.64). Neither central corneal thickness nor intraocular pressure was influenced by age. There was no significant association between central corneal thickness and intraocular pressure.

Keywords: Central corneal thickness, Intraocular pressure, Non-contact tonometry, Ultrasound pachymetry

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INTRODUCTION

The central corneal thickness is one of the ocular biometric indexes used in assessing the corneal health status (Hahn *et al*., 2003). It provides valid information about the physiological condition of the cornea and the possible changes that the tissue may undergo during diseases, trauma and hypoxia. There has been an increasing interest in determining the values and differences in normal central corneal thickness especially now that it is known to play a vital role in refractive surgery decision like Laser *In Situ* keratomileusis (LASIK) and photorefractive keratectomy (PRK).

A consideration of the central corneal thickness (CCT) can have a substantial impact on the reliability of intraocular pressure measurement as a diagnostic tool for glaucoma suspect (Brandt *et al*., 2001). Previous studies indicate that central corneal thickness data can have an influence on the clinical categorisation and risk assessment of individuals with ocular hypertension (Singh *et al*., 2001) or low tension glaucoma (Wu *et al*., 2000). The difference in intraocular pressure (IOP) as a consequence of central corneal thickness effect ranged from 1.1 to 9.8mmHg (Ehlers *et al*., 1975; Whitacre *et al*., 1993; Gupta *et al*., 2006; Kohlhaas *et al*., 2006).

A strong positive correlation between central corneal thickness and intraocular pressure has been reported by previous studies (Iyamu and Ituah, 2008; Sahin *et al*., 2008; Mohamed *et al*., 2009). The aim of this study was to provide average values for the central corneal thickness and a regression model for CCT and intraocular pressure in a predominantly black Nigerian population.

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MATERIALS AND METHODS

Study Setting and Design

This observational, prospective, cross-sectional study was conducted in Optometry clinic at the University of Benin, Nigeria over a period of six months (August 2009 and January 2010). Pretest screening test was conducted, and eligible subjects were identified and complete optometric examination (including visual acuity test with Snellens's chart, anterior segment examination by slit-lamp biomicroscopy, internal examination by direct ophthalmoscopy) was performed on them. Using a table of random numbers (Ogbeibu, 2005), the participants for the study were selected. All participants fulfilled the inclusion criteria: No history of corneal infection/abnormalities, contact lens wear, or systemic disease like diabetes or hypertension, no history of rheumatoid arthritis, ocular trauma or surgery, and intraocular pressure of 10-21mmHg. Participants were aged between 20-69 years and were placed in one of four age groups (20-39, 40-49, 50-59 and 60-69 years) on the basis of age. All the procedures were approved by the departmental research and ethics committee of the University in accordance with the tenets of Helsinki's declaration for human subjects.

Measurement of Intraocular Pressure and Central Corneal Thickness

The Keeler Pulsair EasyEye Non-contact tonometer (Keeler Instruments, USA) was used to measure the intraocular pressure. The subject was comfortably seated with head upright and eyes looking in the primary position of gaze. The tonometer was then directed on the patient's eye and once the beam located the center of the pupil, the instrument automatically fires a jet of air to applanate the cornea, thereby measuring the IOP. Five measurements were obtained. The instrument automatically displayed the average measured intraocular pressure (mIOP). The central corneal thickness was measured with SW-1000P ultrasound pachymeter (Tianjin Suowei Electronic Technology, China). The subject was comfortably seated with the head upright and eyes in the primary position of gaze. The probe was sterilized with 70% alcohol and allowed to air-dry. A drop of topical anaesthetic (Tetracaine HCl 0.1%) was instilled in subject's eye. The probe was carefully aligned perpendicularly to and lightly applanating the cornea. At least ten readings are continuously taken and the average calculated as the measured central corneal thickness (CCT). All measurements were taken between 9am and 12noon to avoid diurnal variation.

Data Analysis

All data were analysed on computer (Statgraphics® Plus ver., 5.1; Statistical graphics Corp, USA and SPSS ver., 10.0; SPSS Inc., Chicago, IL, USA). Measures of spread including standardised kurtosis and standardised skewness were derived. Normality of distribution of data was determined by the spread. The distribution of data was considered normal when the values of the spread lie between -2 and 2. One-way analysis of variance (ANOVA) was used to compare the mean intraocular pressure and central corneal thickness across age groups. The correlation between variables was tested using linear regression analysis. A *p*-value of ≤0.05 was taken as statistically significant.

RESULTS

A total of eighty-five (n=85) subjects with mean age 44.65 ± 15.11years, aged between 20 to 69 years, consisting of 49 males and 36 females were recruited for the study. Regression analysis was performed on the parameters taken for both eyes, and there was a strong correlation between the two eyes (p<0.00001). For this reason only variables for the right eyes were used subsequently throughout the study.

Table 1: Descriptive Statistics of the Measured Variables of the Study Population

Statistics	CCT(μm)	IOP (mmHg)
Count	85	85
Average	550.0	15.0
SD	36.3	2.6
Range	478.0 – 662.0	10.0 – 22.0
Stnd skew	1.7	0.3
Stnd kurt	0.4	0.7
95% CI	542.2 – 557.9	15.3 – 16.4

SD= standard deviation; Stnd skew = standardized skewness; stnd kurt= standardized kurtosis; CI=confidence interval

The descriptive statistics of the measured variables are presented in Table 1. The mean CCT for the study population was 548.2± 32.0µm (range, 478.0- 618.0µm). Analysis of variance performed to the test for differences in mean across the age groups, showed no statistical significance (*F*=1.27, *DF*=3, *P*=0.29). Post hoc test (pair-wise comparison) using Fisher's least significant difference (LSD), showed the highest mean difference of 11.0µm, between 50-59 and 60-69 years old, followed by 9.2µm between 20-39 and 40-49 years old. These mean differences were not statistically significant (*p*>0.05). Table 2 shows the descriptive statistics of the CCT across age group.

Table 2: Descriptive Statistics Central Corneal Thickness across the Age Groups

Statistics	AGE GROUP (YEARS)			
	20-39	**40-49**	**50-59**	**60-69**
Count	32	17	18	18
Average	558.3	549.1	548.7	537.7
SD	32.4	27.3	45.1	39.6
Range	496.0 – 618.0	491.0 – 604.0	487.0 – 601.0	478.0 – 609.0
Stnd skew	0.2	0.6	2.2	0.3
Stnd kurt	-1.0	0.6	1.3	0.8
95% CI	546.6 – 569.9	535.0 – 563.1	526.2 – 571.1	518.0 – 534.4

Table 3: Descriptive Statistics of Intraocular Pressure across Age Groups

Statistics	AGE GROUP (YEARS)			
	20-39	**40-49**	**50-59**	**60-69**
Count	32	17	18	18
Average	15.8	14.5	16.8	16.4
SD	2.8	2.1	2.4	2.6
Range	10.0 – 21.0	11.0 – 18.0	12.0 – 21.0	12.0 – 21.0
Stnd skew	0.1	0.4	-0.6	0.7
Stnd kurt	-0.5	-0.7	-0.4	0.7
95% CI	14.8 – 16.8	13.4 – 15.6	15.7 – 18.0	15.1 – 17.7

Table 4: Descriptive Statistics of Central Corneal Thickness according to Gender

Statistics	GENDER	
	Male	**Female**
Count	49	36
Average	15.7	16.1
SD	2.5	2.8
Range	11.0 – 22.0	10.0 – 21.0
Stnd skew	1.1	-0.7
Stnd kurt	-0.1	-0.5
95% CI	15.0 –16.4	15.2 –17.0

Table 5: Descriptive Statistics of Intraocular Pressure according to Gender

Statistics	Gender	
	Male	**Female**
Count	49	36
Average	552.8	546.3
SD	38.5	33.3
Range	478.0 – 662.0	478.0 – 636.0
Stnd skew	1.1	1.2
Stnd kurt	0.1	0.8
95% CI	541.8 – 563.8	535.0 – 557.5

Figure 1 shows the trend of the average central corneal thickness across the age groups. A regression analysis performed on central corneal thickness and age shows that the association was statistically significant (*r*= -0.25, *p*=0.021). The regression model is represented by: CCT= 571.93 – 0.531*AGE. The model as fitted explains 6.3% of the variability in CCT. From the model, a 10 year increase in age will result in approximately 5.0µm decrease in CCT.

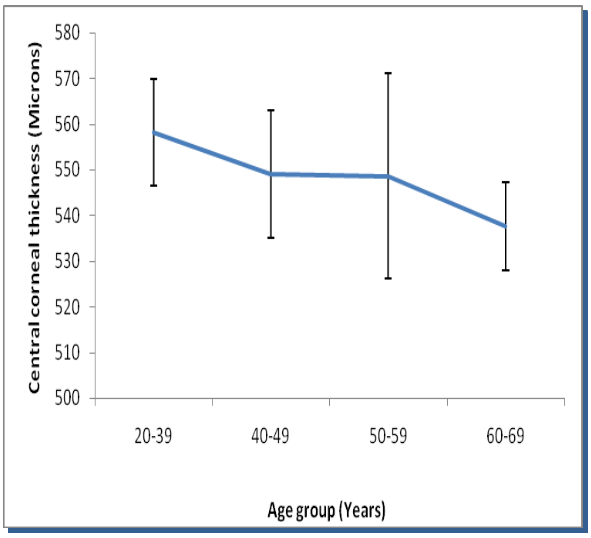

Figure 1: Trend of Central Corneal Thickness according to Age Group

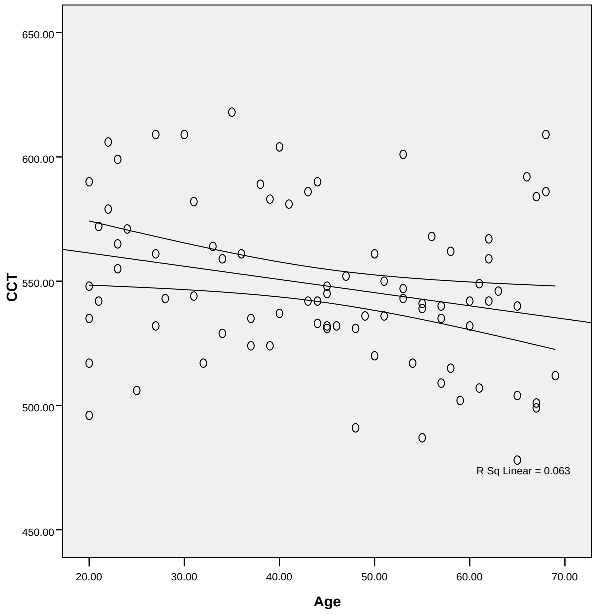

Figure 2: The Correlation of Central Corneal Thickness andAge with the 95% Confidence Interval of the Regression Line (CCT=571.933 – 0.531*AGE)

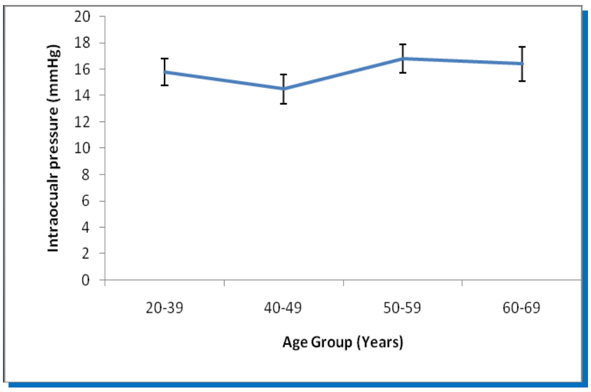

Figure 3: Trend of Intraocular Pressure across Age Groups Studied.

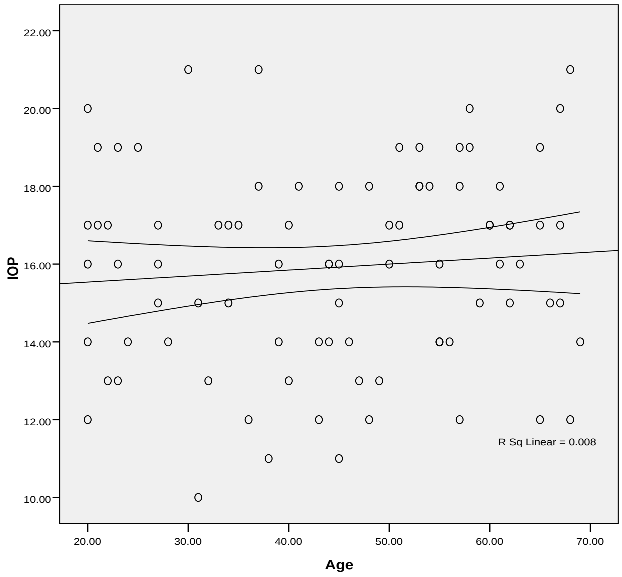

Figure 4: Correlation of Intraocular Pressure and Age with the 95% Confidence Interval of the Regression Line (IOP = 15.23 + 0.015*AGE)

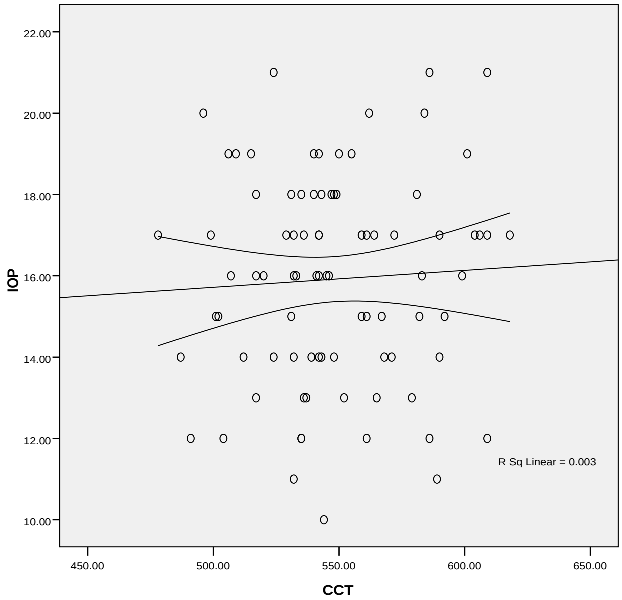

Figure 5: Correlation of Intraocular Pressure and Central Corneal Thickness with 95% Confidence Interval of the Regression Line (IOP = 13.63 + 0.004*CCT)

Figure 2 represents the correlation between CCT and Age. The mean IOP of the studied population was 15.0 ± 2.6mmHg.The mean difference in IOP across the age groups was statistically significant (ANOVA: F=2.89, df=3, P=0.04). Post hoc test with Fisher's LSD showed that the mean differences in IOP of 2.3mmHg (between 40-49 and 50-59 age groups) and 1.9mmHg (between 40-49 and 60-69 age groups were statistically significant (Table 3).

The trend of intraocular pressure across the age groups studied is represented in Figure 3. However, the association between IOP and age was not statistically significant (r=0.091, p=0.41).The linear regression model is: IOP=15.23+0.015*AGE (Figure 4). The difference in mean CCT between males and females was not statistically significant (unpaired t- test: t=0.82, DF=84, P=0.41) (Table 4).

Similarly, the difference in mean IOP between males and females was not significant (t=0.68, DF=3, P=0.50) (Table 5). Regression analysis performed on intraocular pressure and central corneal thickness, shows that the correlation between the variables was not significant (r=0.052, P=0.64). The linear regression model is represented by: IOP = 13.63 + 0.004*CCT (Figure 5).

DISCUSSION

The potential for central corneal thickness to significantly impact on the intraocular pressure, including diagnosis and management options of glaucoma, has aroused great interest in its distribution in different populations (Dueker *et al*., 2007) and races (Hahn *et al*., 2003; Shimmyo *et al*., 2003; Aghaian *et al*., 2004; Kohlhaas *et al*., 2006; Mercieca *et al*., 2007; Iyamu and Ituah, 2008; Chen *et al*., 2009). Several factors affect the central corneal thickness including race, ethnicity, age and gender. The reason for carrying out the present study was to provide average values of central corneal thickness for a wide age range of adult Nigerian population. It was also aimed to provide a regression equation that can be employed to predict the relationship between central corneal thickness and intraocular pressure in black African population without glaucoma.

This study shows a mean CCT of 550.0 ± 36.3µm for the entire adult population of Nigerians without glaucoma. Previous studies have reported mean CCT among Nigerians to range from 535.0 to 551.6µm (Mercieca *et al*., 2007; Iyamu and Ituah, 2008). Reported CCT among African-Americans ranges from 521.0 to 555.0µm (La Rosa *et al*., 2001; Shimmyo *et al*., 2003; Aghaian *et al*., 2004). This present result however, implies that the average CCT of African-Americans may be different from values reported for black Africans. This difference may be related to the fact that self reported racial background among African - Americans may not be homogenous. Consequently, average CCT for African-Americans should not be used to describe Nigerian adults.

In the study of Mercieca and colleagues (2007), the mean age of their normotensive subjects was 63.1 ± 11.2 years as against the 44.7 ± 15.1 years of this study. This difference in mean age probably explains why their mean CCT was smaller than the current value (548.2 ± 32.0µm). The average CCT of this study was smaller than the 563.0 ± 38.0 and 562.8 ± 31.3µm reported for Caucasians by Aghaian *et al*. (2004) and Semes *et al*. (2006). This value was close to that of the Taiwanese Chinese (554.0 ± 29.0µm) (Chen *et al*., 2009).

For the Spaniards, Lleo *et al*. (2003) reported an average of 546.9 ± 42.4µm which was also close to the average value for our studied sample. Again, comparing the average value of this study with average CCT values from other African countries, lower CCT values of 520.15 ± 58.1µm and 529.29 ± 35.9µm were reported in Sudan (Mohamed *et al*., 2009) and Cameroon (Eballe *et al*., 2010) respectively. Eballe and co-workers chose to work with CCT values just between 527 and 560µm, thereby excluding a lot of values outside this range and possibly explains the lower average value documented in their study (Eballe *et al*., 2010). This shows that the variation in CCT values among blacks of African descent goes beyond boundaries of race.

Studies have also concluded that age group is significantly related to CCT. The analyses from this study show that CCT decreases with age. The mean CCT (537.7 ± 39.6) of 60-69 years old in the present study is similar to the average value reported (535.0 ± 38.0µm) by Mercieca and co-workers for Nigerians (mean age=63.1 ± 11.2 years) (Mercieca *et al*., 2007). In our study, the stratification of the age groups was similar to that of Hahn and colleagues (2003). Although, these two studies showed that decreasing values of CCT were significantly related to older age, the authors they did not present the regression equation for the prediction of CCT with increasing age (Hahn *et al*., 2003; Mercieca *et al*., 2007). From our study, based on the linear model of Age-CCT relationship equation (CCT = 571.933 - 0.531*AGE), we could predict that a 10-year increase in age would lead to approximately a 5.0µm decrease in CCT. The forecast of 5.0µm decrease in CCT per decade from this study was consistent with the findings of Foster *et al.* (1998) and Alsbirk (1978). Aghaian *et al.* (2004) claimed that there was an inverse relationship between age and CCT (r = -0.13, p = 0.0002). In their study population that comprised Asians, Caucasians, Hispanics and Africa-Americans, the CCT decreases by 3.0µm per decade. Wong *et al*. (2002) also reported a negative correlation (r = - 0.237, p<0.01) between CCT and age in adult Hong Kong Chinese. The thinner CCT reported for older age group has been attributed to a decline in the density of keratocytes and a probable breakdown in the collagen fibers in the aging cornea (Faragher *et al*., 1997).

Previous studies in Nigeria described no significant association between CCT and age in normotensives (Iyamu and Ituah, 2008). This discrepancy may be due to the narrow age range of the subjects studied and the small sample size. Eysteinsson *et al*. (2002) found no association between central corneal thickness and age. Similarly, Mohamed *et al*. (2009), found no significant association between CCT and age in adult Sudanese population. Although males had slightly thicker CCT compared to females (males: mean, 552.8 ± 38.5µm; females: mean, 546.3 ± 33.3µm), the present results showed that gender had no significant effect on CCT among Nigerian adults.

This was consistent with the study of Aghaian and co-authors (2004) who reported that the difference in mean CCT between males and females was not significant (males: mean, 544.8 ± 37.6 µm; females: mean, 541.3 ± 37.1µm). Eysteinsson *et al.* (2002) also reported that gender-related difference in CCT was not significant. Mercieca *et al*. (2009) found a significant (p = 0.035) gender-related difference in CCT of Nigerian adults (males: mean, 541.0 ± 47.0µm; females: mean, 522.0 ± 22.0µm). Shimmyo *et al.* (2003) and Yagei *et al*. (2005) also reported that men had thicker corneas than their female counterparts. Similarly, Hahn and colleagues reported that male Latinos with normal eyes had significantly (p = 0.006) thicker corneas than the females (Hahn *et al*., 2003).

The mean IOP in the studied population was 15.0 ± 2.6mmHg. The effect of age group on measured intraocular pressure (mIOP) was significant (p=0.04) indicating that CCT did not significantly affect measured intraocular pressure in subjects with normal IOP.This was consistent with the findings of some authors, who have noted non-contact tonometry to be minimally affected by CCT (Masumoto *et al*., 2000). However, a few studies have reported a significant association between CCT and IOP among normotensive groups (Cho and Lam, 1999; Eysteinsson *et al*., 2002). Intraocular pressure measured by both non-contact tonometry (r = 0.515, p<0.0001) and Goldmann applanation tonometry (r = 0.237, p<0.05) was significantly correlated with CCT among normotensives (Harada *et al*., 2008).

Central corneal thickness has been shown to be an important variable that affect the intraocular pressure measurements in patients without glaucoma (Wolfs *et al*., 1997). Kohlhaas and colleagues (2006) found a significant association between measured IOP and central corneal thickness in normotensives. They represented their linear regression model by the equation: ∆IOP = 23.28 – 0.0423*CCT. Using this equation, they calculated correction values (∆IOPs) for applanation IOP readings for different CCTs, which was termed “Dresdner correction table”. ∆IOP (in mmHg) is approximately 0 at a CCT of 550µm. The ∆IOP was used to adjust the measured IOP to obtain the real IOP of the patients. The clinical implication of the relationship of IOP and CCT relates to the fact that IOP readings measured by applanation tonometry may depend on the rigidity of the cornea, which is related to CCT (Goldmann and Schmidt, 1957).

The American Academy of Ophthalmology (2006) claimed that the relationship between CCT and IOP in not linear, and there is no acceptable universal algorithm. Other studies have confirmed that the relationship between CCT and IOP in normal subjects demonstrated a positive linear correlation (Iyamu and Ituah 2008; Sahin *et al*., 2008; Mohamed *et al*., 2009; Eballe *et al*., 2010). Kotecha (2005) claimed that CCT alone cannot account for all the variation in measured IOP amongst individuals, and it is likely that complex corneal biomechanical properties have an important influence on IOP measurement. Gender had no effect on measured intraocular pressure.

CONCLUSION

No significant association was found between central corneal thickness and intraocular pressure. Neither age nor gender affected central corneal thickness.

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